<u>CLAIMS</u>:

1. A transmitter comprising:

N transmit antennas, where N>=2;

wherein the transmitter is adapted to transmit a respective one of N transmit signals from each of the N antennas, the N transmit signals collectively containing a plurality N of main signals and a plurality of delayed main signals each delayed main signal being a delayed version of one of the main signals, wherein each transmit signal comprises a combination of a respective main signal of the plurality of main signals and at least one respective delayed main signal of the N delayed main signals.

2. The transmitter of claim 1 wherein the N transmit signals comprise a Jth transmit signal $Transmit_J$ from antenna J=1,…,N, and wherein $Transmit_J$ comprises:

$$Transmit_J = \alpha_J T_J(S_J) + \sum_{i=1}^{K_J} \alpha_{iJ} T_{i,J}\left(S_{iJ}(t - D_{iJ})\right)$$

S_J = is the Jth main signal of the plurality of main signals;

α_J = is a virtual spatial reflector applied to the Jth main signal;

T_J = is a transformation applied to the Jth main signal;

K_J is a number of delayed signals included in the Jth transmit signal;

α_{iJ} = is a virtual spatial reflector applied to the ith delayed signal included in the Jth transmit signal;

S_{iJ} , $i=1,...,K_J$ are the signals which are to be delayed and included in the Jth transmit signal where each $iJ \in 1,\ldots,N$;

D_{iJ} = is a delay applied to signal S_{iJ};

T_{iJ} = is a transformation applied to the ith delayed signal included in the Jth transmit signal.

3. The transmitter of claim 2 wherein each transmit signal comprises a CDMA (Code Division Multiple Access) signal.

4. The transmitter of claim 3 wherein each main signal comprises a respective combined set of at least one code separated channel.

5. The transmitter of claim 4 wherein each transmit signal further comprises at least one additional code separated channel not included in any main signal.

6. A transmitter for transmitting a first main signal $S_A(t)$ and a second main signal $S_B(t)$, the transmitter comprising:

a first antenna and a second antenna;

a first delay element for delaying the first main signal $S_A(t)$ to produce a first delayed signal $S_A(t-D1)$ where D1 is a first delay;

a second delay element for delaying the second main signal $S_B(t)$ to produce a second delayed signal $S_B(t-D2)$ where D2 is a second delay;

wherein a first linear combination of one of the main signals and one of the delayed signals is transmitted from the first antenna and a second linear combination of the other of the main signals and the other of the delayed signals is transmitted from the second antenna.

7. The transmitter according to claim 6 wherein the first main signal and the second main signal are each CDMA (Code Division Multiple Access) signals.

8. The transmitter according to claim 6 wherein the first linear combination comprises:

$$X_A(t) = \alpha_{A1} S_A(t) + \alpha_{A2} S_A(t - D1)$$

and the second linear combination comprises:

$$X_B(t) = \alpha_{B1} S_B(t) + \alpha_{B2} S_B(t - D2)$$

wherein α_{A1}, α_{A2}, α_{B1}, α_{B2} form a set of virtual spatial reflectors chosen such that a resulting channel matrix H yields a well conditioned H^*H for a particular noise environment where D1 and D2 are delays and where H^* is the complex conjugate of H.

9. The transmitter according to claim 6 wherein the first linear combination comprises:

$$X_A(t) = \alpha_{A1} S_A(t) + \alpha_{B2} S_B(t - D1)$$

and the second linear combination comprises:

$$X_B(t) = \alpha_{B1} S_B(t) + \alpha_{A2} S_A(t - D2)$$

wherein α_{A1}, α_{A2}, α_{B1}, α_{B2} form a set of virtual spatial reflectors chosen such that a resulting channel matrix H yields a well conditioned H^*H for a particular noise environment where D1 and D2 are delays and where H^* is the complex conjugate of H.

10. The transmitter according to claim 7 further comprising:

a scrambling circuit for scrambling a first signal to produce the first main signal and for scrambling a second signal to produce the second main signal, the first signal and the second signal being scrambled with an identical scrambling code.

11. The transmitter according to claim 7 further comprising:

a scrambling circuit for scrambling a first signal to produce the first main signal and for scrambling a second signal to produce the second main signal, the first signal and the second signal being scrambled with different scrambling codes.

12. The transmitter according to claim 11 wherein each delay implemented in one of the delay elements is selected to provide enough separation between the scrambling code and a version of the scrambling code delayed by the delay such that the scrambling code and the scrambling code delayed by the delay are substantially orthogonal to each other.

13. The transmitter according to claim 11 further comprising:

a demultiplexer for splitting a symbol stream into symbols included in said first signal and said second signal.

14. The transmitter according to claim 6 adapted to transmit from each antenna a respective CDMA (Code Division Multiple Access) signal containing a plurality of code separated channels, the plurality of code separated channels comprising:

a respective first set of at least one channels which are generic to multiple users;

a respective second set of at least one channels which are user specific; and

a respective third set of channels which are user specific and which function as one of said main signals.

15. The transmitter according to claim 6 wherein the first main signal and the second main signal are each OFDM (Orthogonal Frequency Division Modulation) signals.

16. The transmitter according to claim 15 wherein the first linear combination comprises:

$$X_A(t) = \alpha_{A1} S_A(t) + \alpha_{A2} S_A(t - D1)$$

and the second linear combination comprises:

$$X_B(t) = \alpha_{B1} S_B(t) + \alpha_{B2} S_B(t - D2)$$

wherein α_{A1}, α_{A2}, α_{B1}, α_{B2} form a set of virtual spatial reflectors chosen such that a resulting channel matrix H yields a well conditioned H^*H for a particular noise environment and

where D1 and D2 are delays and where H^* is the complex conjugate of H.

17. The transmitter according to claim 15 wherein the first linear combination comprises:

$$X_A(t) = \alpha_{A1} S_A(t) + \alpha_{B2} S_B(t - D1)$$

and the second linear combination comprises:

$$X_B(t) = \alpha_{B1} S_B(t) + \alpha_{A2} S_A(t - D2)$$

wherein α_{A1}, α_{A2}, α_{B1}, α_{B2} form a set of virtual spatial reflectors chosen such that a resulting channel matrix H yields a well conditioned H^*H for a particular noise environment and where H^* is the complex conjugate of H.

18. The transmitter according to claim 15 further comprising:

a forward error correction block for performing forward error correction on an incoming bit stream to generate a coded bit stream;

a symbol mapping function for mapping the coded bit stream to a first modulation symbol stream;

a demultiplexing function adapted to divide the modulation symbol stream into second and third modulation symbol streams;

a first IFFT (Inverse Fast Fourier Transform) function, first prefix adding function and first windowing filter adapted to process the second modulation symbol stream to generate the first main signal;

a second IFFT (Inverse Fast Fourier Transform) function, second prefix adding function and second windowing filter adapted to process the third modulation symbol stream to generate the second main signal.

19. The transmitter according to claim 16 wherein α_{A1}, α_{A2}, α_{B1}, α_{B2} are chosen to optimize at least one of the following constraints:

a) balanced energy: $|\alpha_{A1}|^2 + |\alpha_{A2}|^2 + |\alpha_{A1} + \alpha_{A2}|^2 = |\alpha_{B1}|^2 + |\alpha_{B2}|^2 + | \alpha_{B1} + \alpha_{B2}|^2$;

b) there is no large notch in frequency domain;

c) maximize capacity; and

d) meet a specified spectrum mask.

20. A receiver for receiving a signal transmitted over a wireless channel from a transmitter having a plurality N of transmit antennas, wherein the transmitter is adapted to transmit a respective one of N transmit signals from each of the N antennas, the N transmit signals collectively containing a plurality N of main signals and a plurality of delayed main signals each delayed main signal being a delayed version of one of the main signals, wherein each transmit signal comprises a combination of a respective main signal of the plurality of main signals and at least one respective delayed main signal of the N delayed main signals, the receiver comprising:

at least one receive antenna, each receive antenna receiving a respective receive signal over the wireless channel from the transmitter;

receive signal processing circuitry adapted to perform receive processing for each of the N main signals and each of the N delayed main signals.

21. The receiver of claim 20 wherein there are less than N receive antennas.

22. The receiver of claim 20 wherein there is only one receive antenna.

23. The receiver of claim 20 wherein all signals are CDMA (Code Division Multiple Access) signals.

24. The receiver of claim 23 wherein the receive signal processing circuitry comprises:

a finger detector configured to process each receive signal to identify multi-path components transmitted by each antenna, the multi-path components comprising at least one pair of multi-path components comprising a first multi-path component and a second multi-path component which is later than the first multi-path component by the delay introduced at the transmitter.

25. The receiver of claim 24 wherein the receive signal processing circuitry comprises de-scrambling and de-spreading functions which produce de-spread signals for each multi-path component, the receiver further comprising:

a virtual array processor for performing combining of the de-spread signals.

26. A receiver for receiving a signal transmitted over a wireless channel from a transmitter having a plurality N of transmit antennas, wherein the transmitter is adapted to transmit a respective one of N transmit signals from each of

the N antennas, the N transmit signals collectively containing a plurality N of main signals and a plurality of delayed main signals each delayed main signal being a delayed version of one of the main signals, wherein each transmit signal comprises a combination of a respective main signal of the plurality of main signals and at least one respective delayed main signal of the N delayed main signals, the receiver comprising:

at least one receive antenna, each receive antenna receiving a respective receive signal over the wireless channel from the transmitter;

for each receive antenna, a respective over-sampling analog to digital converter which samples the respective receive signal and a respective sample selector adapted to produce a respective plurality of sample streams;

signal processing circuitry adapted to perform receive processing for each of the sample streams to produce pre-combined signals;

a MIMO (Multiple Input Multiple Output) decoder adapted to perform MIMO processing on the pre-combined signals.

27. The receiver of claim 26 wherein there are less than N receive antennas.

28. The receiver of claim 26 wherein there is only one receive antenna.

29. The receiver of claim 26 wherein each transmit signal comprises a main signal and N-1 delayed signals, and wherein each over-sampling analog to digital converter performs N times over-sampling.

30. The receiver of claim 28 wherein each transmit signal comprises one main signal and one delayed main signal, wherein

two-times over-sampling is performed, and wherein the sample selector takes all even samples to generate a first of the sample streams, and takes all odd samples to generate a second of the sample streams.

31. A system comprising:

a transmitter according to claim 1;

a receiver comprising:

at least one receive antenna, each receive antenna receiving a respective receive signal over the wireless channel from the transmitter;

receive signal processing circuitry adapted to process the receive signals.

32. The system of claim 31 wherein the receive signal processing circuitry is adapted to perform receive processing for each of the N main signals and each of the N delayed main signals.

33. The system of claim 31 wherein the N transmit signals comprise a Jth transmit signal $Transmit_J$ from antenna J=1,…,N, and wherein $Transmit_J$ comprises:

$$Transmit_J = \alpha_J T_J(S_J) + \sum_{i=1}^{K_J} \alpha_{iJ} T_{i,J}(S_{iJ}(t - D_{iJ}))$$

S_J = is the Jth main signal of the plurality of main signals;

α_J = is a virtual spatial reflector applied to the Jth main signal;

T_J = is a transformation applied to the Jth main signal;

K_J is a number of delayed signals included in the Jth transmit signal;

α_{iJ} = is a virtual spatial reflector applied to the ith delayed signal included in the Jth transmit signal;

S_{iJ} , $i=1,\ldots,K_J$ are the signals which are to be delayed and included in the Jth transmit signal where each $iJ \in 1,\ldots,N$;

D_{iJ} = is a delay applied to signal S_{iJ};

T_{iJ} = is a transformation applied to the ith delayed signal included in the Jth transmit signal.

34. The system of claim 32 adapted to transmit and receive CDMA (Code Division Multiple Access) signals.

35. The system of claim 34 wherein each main signal comprises a respective combined set of at least one code separated channel.

36. The system of claim 31 wherein there are two transmit signals, and the main signals comprise a first main signal $S_A(t)$ and a second main signal $S_B(t)$, the transmitter further comprising:

a first antenna and a second antenna;

a first delay element for delaying the first main signal $S_A(t)$ to produce a first delayed signal $S_A(t-D1)$ where D1 is a first delay;

a second delay element for delaying the second main signal $S_B(t)$ to produce a second delayed signal $S_B(t-D2)$ where D2 is a second delay;

wherein a first linear combination of one of the main signals and one of the delayed signals is transmitted from the first antenna and a second linear combination of the other of the main signals and the other of the delayed signals is transmitted from the second antenna.

37. The system of claim 31 wherein there are less than N receive antennas.

38. The system of claim 31 wherein there is only one receive antenna.

39. The system of claim 32 wherein the receive signal processing circuitry comprises:

a finger detector configured to process each receive signal to identify multi-path components transmitted by each antenna, the multi-path components comprising at least one pair of multi-path components comprising a first multi-path component and a second multi-path component which is later than the first multi-path component by the delay introduced at the transmitter.

40. The receiver of claim 39 wherein the receive signal processing circuitry comprises de-scrambling and de-spreading functions which produce de-spread signals for each multi-path component the receiver further comprising:

a virtual array processor for performing combining of the de-spread signals.

41. The system according to claim 31 adapted to transmit and receive OFDM (Orthogonal Frequency Division Modulation) signals.

42. The system according to claim 36 adapted to transmit and receive OFDM (Orthogonal Frequency Division Modulation) signals wherein the transmitter further comprises:

a forward error correction block for performing forward error correction on an incoming bit stream to generate a coded bit stream;

a symbol mapping function for mapping the coded bit stream to a first modulation symbol stream;

a demultiplexing function adapted to divide the modulation symbol stream into second and third modulation symbol streams;

a first IFFT (Inverse Fast Fourier Transform) function, first prefix adding function and first windowing filter adapted to process the second modulation symbol stream to generate the first main signal;

a second IFFT (Inverse Fast Fourier Transform) function, second prefix adding function and second windowing filter adapted to process the third modulation symbol stream to generate the second main signal.

43. The system according to claim 41 wherein the receiver comprises:

at least one receive antenna, each receive antenna receiving a respective receive signal over the wireless channel from the transmitter;

for each receive antenna, a respective over-sampling analog to digital converter which samples the respective signal and a respective sample selector adapted to produce a respective plurality of sample streams;

signal processing circuitry adapted to perform receive processing for each of the sample streams to produce pre-combined signals;

a MIMO (Multiple Input Multiple Output) decoder adapted to perform MIMO processing on the pre-combined signals.

44. The system of claim 43 wherein there are less than N receive antennas.

45. The system of claim 43 wherein there is only one receive antenna.

46. The system of claim 43 wherein each transmit signal comprises a main signal and N-1 delayed signals, and wherein each over-sampling analog to digital converter performs N times over-sampling.

47. The system of claim 45 wherein each transmit signal comprises one main signal and one delayed main signal, wherein two-times over-sampling is performed, and wherein the sample selector takes all even samples to generate a first of the sample streams, and takes all odd samples to generate a second of sample streams.

48. A method of transmitting comprising:

delaying each of N main signals by each of at least one respective delay to produce at least one respective delayed main signal;

transmitting from each of N >=2 antennas a respective signal comprising one of the main signals combined with at least one of the delayed main signals.

49. A method of receiving comprising:

at a single receive antenna, receiving over a wireless channel a received signal produced in accordance with the method of claim 48;

processing the received signal to produce at least two signals which are mathematically equivalent to two signals which would be received over two different receive antennas;

processing the two signals as if they were received over two different antennas.